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Ionic Source for a Mass Analyzer

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Patent claims:

1. Ionic source for a mass analyzer, in which a solid sample is irradiated using laser light and the ions emitted from the sample are removed using fields from the sample, characterized by the laser beam (1) in the reflected light impacting the sample surface (2) vertically, and before entry of the ions (3) in the mass analyzer (4), a pre-specified energy area is selected using an energy filter (5-7, 11, 15) of the electrostatic mirror type and cylinder geometry ions (3).

2. Ionic source according to claim 1, characterized by the sample (9) being arranged vertically to the symmetry axis (10) of the energy filter (5-7, 11, 15) in the energy filter on a holding fixture (11) in the energy filter in

such a way that a deflection of the emitting ions (3) by a tone reflector (8) in the direction of the energy selector (5-7, 11, 15) takes place, with the laser beam (1) being aimed in the direction of the sample surface (2).

3. Ionic source according to claim 2, characterized by the ionic reflector (8) sealing off the energy filter (5-7, 11, 15) up to a passage aperture (12) for the laser beam (1) on one side.

4. Ionic source according to claim 2 or 3, characterized by the ionic reflector (8) being a plate with conductive metallized focusing lens (13 and 14) in the passage aperture (12) or only a conductive metallized focusing lens (14) for the laser beam (1).

5. Ionic source according to claim 1, characterized by the sample (9) being arranged outside of the energy filter (5-7, 11, 15) vertical to the symmetry axis (10) of the energy filter, with the sample surface (2) pointing to the energy filter (5-7, 11, 15), and the laser beam (1) entering the energy filter laterally and being reflected in the symmetry axis (10).

6. Ionic source according to claim 5, characterized in such a way that concentric to the symmetry axis (10), a holding cylinder (15) for a deflecting mirror (16) and a focusing lens (14) or a concave mirror (18, 19) with deflecting- and focusing-properties with lateral entry aperture (20) is arranged for the laser beam (1).

7. Ionic source according to claim 6, characterized by the focusing lens (14) being metallized with a conductive layer (26) or a protective glass also (17) being arranged in front of the focusing lens (14).

8. Ionic source according to claim 1 or one of the following, characterized by the holding fixture (11 or 15) of the sample (9) or of the optical system (14, 16, 18, 19) of parts of it on the symmetry axis (10) in the energy filter (5-7, 11, 15) being a component of the ionic optical system of the energy filter.

9. Ionic source according to claim 1 or one of the following, characterized by a light optic observation of the sample surface (2) and a light spectrum examination of the plasma (3) being simultaneously executable.

Description:

The invention concerns an ionic source for a mass analyzer in which a solid sample is irradiated using laser light and the ions emitted from the sample are removed using fields of the sample.

Analyzing thin layers in transmission is already known (DE-OS 2141387). In addition, a reflected light laser probe with oblique exposure to light, relatively long-focus focusing and thus lower spatial resolution is known (Journal of Analytical Chemistry. USSR 29, 1516 (1974)).

With the first procedure, only layers in the thickness range of /um can be examined, which makes an expensive sample preparation necessary. In the case of the reflecting light-laser probe, the sloping exposure of the laser light produces an unsymmetrical ionic emission, which again is disadvantageous for the subsequent mass spectrometries. Moreover, the long-focal-length focusing lens used delivers poor spatial resolution.

Both procedures have the disadvantage that they require additional energy filters if the highest mass resolution is desired.

The task of the invention now consists of improving an ionic source of the type initially named in such a way that it features a high spatial resolution of the laser focus, because relatively short-focal-length focusing lenses can be used closely above the sample surface and the energy intensity for subsequent mass spectrometers is reduced. The samples can be measured without further preparation or after punching out simple sample pills, for instance.

The solution of this task is shown in the characteristic of claim 1 and for examples listed in the characteristics 2 – 9.

With the ionic source according to the invention, a laser beam is focused and matter is vaporized, ionized and then analyzed on a solid sample or a sample pill using mass- and/or light-spectroscopy. The beam can be pulsating or continuous, in order to be useable for subsequent time-of-flight mass analysis, mass filters or mass spectrographs for stratigraphic analysis or continuous scanning. According to the invention, the energy intensity of the ions is nearly disposed of by the energy filter; i.e., practically only ions of the same energy reach the mass analyzer's point of entry. The volume to be analyzed is essentially determined by the focal length of the focusing optic and laser parameters used. With sufficiently short focal length, micro analyses in the ,um- range are even possible. Since it permits mass spectrometers to verify even more ions, the ionic source according to the invention can offer a highly sensitive, spatially resolutive analysis system.

In summary, the potentially short focal length of the focusing system causes a high spatial resolution in the reflecting light and the ionic source creates a simple connection to the energy filter, ionic optical system, etc. Consistent ionic flight paths can be

created for the entire emission cone-shaped shell (not only a path as with asymmetrical illumination), so that little time-of-flight blurriness arises with time-of-flight mass separation. The material removal from the sample is done rotationally symmetric, which is advantageous for deep layer analyses. Structurally, the ionic source can if necessary be assembled with the laser- and/or mass spectrometer into a simple linear arrangement, especially with the use of sample pills. A simultaneous light optic spectral analysis is possible.

The invention will be explained in more detail on the basis of the following design examples using figures 1 to 6, in which the figures in the profile each time represent schematic ionic source arrangements.

Figure 1 shows a cylinder-shaped case 22, in which the

energy selector or rather the energy filter 5, 6, 7 and the mass analyzer 4 are arranged rotation-symmetrically to the symmetry axis 10 back-to-back. The energy filter consists of cylinder surfaces 5 and 6, concentrically arranged to each other, as well as two apertures 7 on either side, which form two ring slots with the inner cylinder 6, through which the ions 3 of the sample surface 2 are energy-selective focused above electrostatic fields between the cylinders 5 and 6 or 7 on the symmetry axis 10. The sample 9 is attached rotationally symmetric on the front side of a cylinder-shaped case holding fixture 11 within the energy filter 5, 6 to the symmetry axis 10. The cylinder case 11 can be a component of the energy filter. The laser light 1 emerges through a focusing lens 14 or 25 (see figure 3) vertically on the sample surface 2, in which the sample itself is arranged vertically to the symmetry axis 10 and the laser beam 1 is led into the symmetry axis 10. The focusing lens 14 can be attached here in an opening 12 (see the partial sketch according to figure 2) of an ionic reflector 8, in which the ionic reflector 8 – as depicted in figure 1 – can form the front side of the case 22.

Figure 2 shows the deflection of ions in the energy filter and particularly through the ionic reflector 8 in more detail. The ions 3 emitting from the sample surface 2 initially fly in the direction of illuminating beam 1, are deflected by the ionic reflector 8 by 180 degrees and then energy-selectively filtered by the energy filter 5 to 7 according to figure 1. The laser beam 1 is focused through a short-focal-length lens 14 on the sample surface 2. The lens 14 can itself be attached in a conductive metallized plate 13, which closes the aperture 12 in the ionic reflector 8.

The laser beam 1 can be aligned over a deflecting mirror 27 on the

symmetry axis 10, in which if need be this partially permeable deflecting mirror 27 permits the simultaneous light-optic observation 28 in the symmetry axis 10. In addition, a shield 23 can be arranged around the holding fixture 11 for the sample 9; this shield is then a component of the energy filter. Furthermore, it is possible to cool or adjust the sample 9 using known methods. The lens 14 can also be adjusted.

Instead of the lens 14 according to figure 2 and the single-sided metallized plate 13, figure 3 shows a concave lens 25, which closes the passage opening 12 in the ionic reflector 8. It is also metallized with a conductive layer 26.

Figure 4 again shows a case 22, in which an energy filter 5 to 7 is arranged, which corresponds to the one according to figures 1 to 3. In contrast to the arrangement in figure 1, however, the sample is arranged outside of the energy filter 5 to 7, and in fact outside of case 22 in front of the passage opening 12 in the ionic reflector 8 as well. The sample 9 itself is vertically aligned with the symmetry axis 10 and is adjustable. The sample surface 2 is again impacted by a laser beam 1,

which in the present case, though, radiates laterally, especially vertically to the symmetry axis 10, and is aligned with the symmetry axis 10 using reflection or other optical measures. It emerges vertically on the sample surface 2, to be ablated by the ions 3 and led through the energy filter 5 to 7. They can be subjected to an intermediary focusing 24 before they enter into the mass analyzer. Energy selector 5 to 7, intermediary focusing 24 and mass analyzer 4 can again be compactly arranged back-to-back along the symmetrical axis 10.

The insertion of the laser beam 1 into the symmetry axis 10 is illustrated more precisely in the detail sketch according to figure 5 (or according to figure 6). The laser beam 1 emerges through an opening 20 into a

cylinder-formed holding fixture 15 for a deflecting mirror 16 as well as the focusing lens 14 arranged on the front-side. The focusing lens 14 is directed towards the sample surface 2, and, if need be, metallized with a metal layer 26. Between focusing lens 14 and sample surface 2, a conductive layer 17 is arranged that is permeable for the laser light 1. The ions 3 are removed from the sample surface 2 of the sample 9 without deflection of their flight-path by the energy selector or energy filter 5 to 7. The holding fixture 15 for the mirror 16 as well as the focusing lens 14 can again be components of the energy filter 5 to 7; i.e., the holding fixture 15 is arranged within the energy filters 5 to 7 on the rotational symmetry axis 10. A deflecting mirror 27 can be arranged in the incident laser beam 1 corresponding to the deflecting mirror according to figure 2; this mirror allows the direct observation 28.

Figure 6 shows a further detail for the holding fixture 15 for use in the case 22 or the energy filter 5 to 7 according to figure 4. The laser beam 1 emerges through the opening 22 into the cylinder-formed holding fixture 15, and while doing so is aligned with the rotational symmetry axis 10 by a

parabolic reflector 18, 19 and simultaneously focused on the sample surface 2 of sample 9. The holding fixture 15 can in turn be made so that it is adjustable in relation to the energy filter 5 to 7. Likewise, the light optic observation in accordance with figure 5 is possible.

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Fig. 4

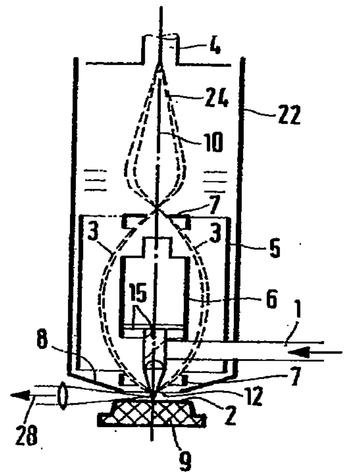

Fig. 6

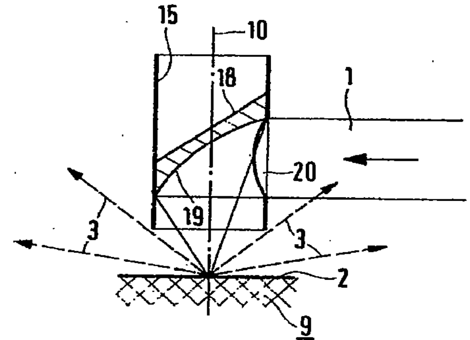

Fig. 5

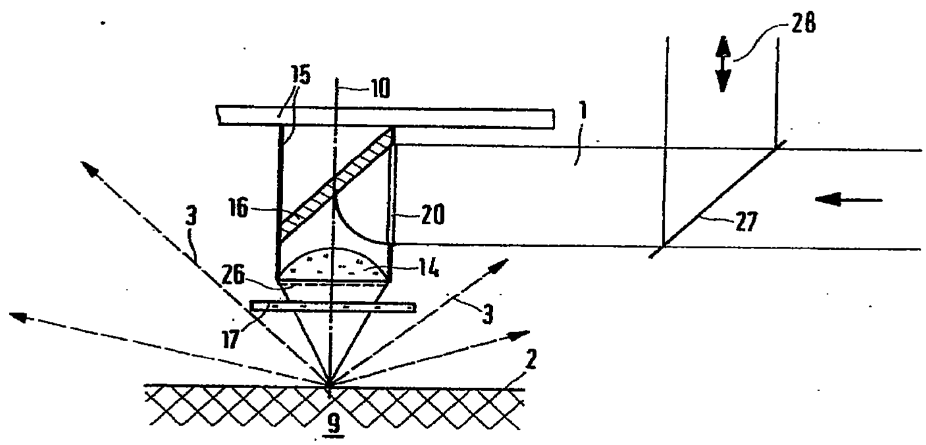

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Fig. 1

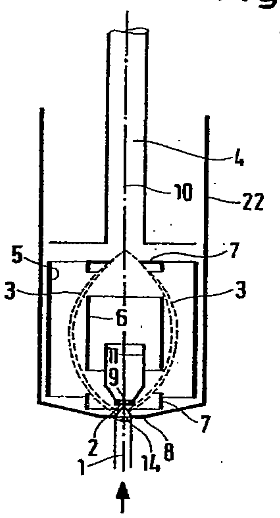


Fig. 3

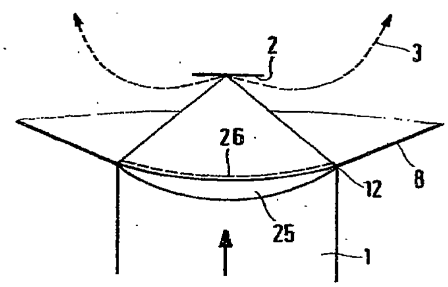
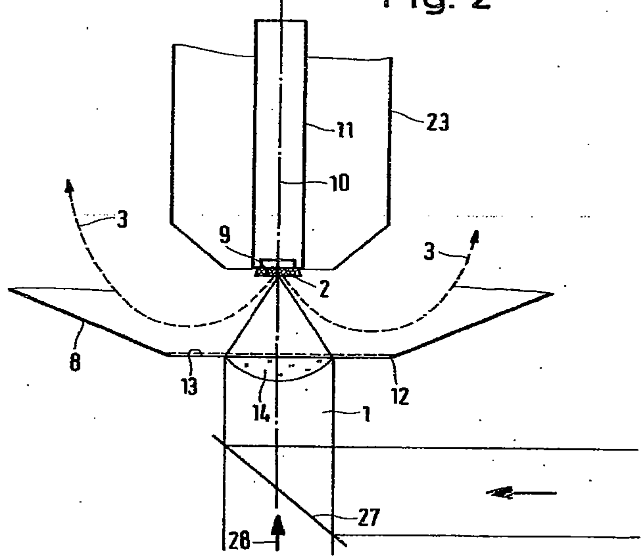


Fig. 2



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